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ABSTRACT

One factor which limits efforts to increase the number of black health professionals is performance in science courses at the college level. This study is one of several designed to identify factors which lead to success in the sciences at Xavier University of Louisiana, a small, historically black institution in New Orleans. The current investigation used linear regression analysis to identify variables which predict grades in organic chemistry at Xavier University. When only measures available on admission to college were used, high school grade point average was the best predictor for both semesters of organic chemistry. The accuracy of prediction was improved marginally by adding the ACT Composite score for the first semester only. When grades earned in previous chemistry courses were used, prediction improved markedly, as expected. The best predictor of grades for the first semester of organic chemistry was grade in the second semester of first-year chemistry, with grade in the first semester of first-year chemistry improving prediction somewhat. Results of the study should be used to improve advising of students, and provide direction in developing intervention strategies to help the underprepared. An extensive list of reference is appended. (PS)

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Predictors of Organic Chemistry Grades for Black Americans

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Abstract: There is an urgent national need to increase the low numbers of blacks in the health professions, since their underrepresentation is directly related to the relatively poor health care available to black America. One factor which limits efforts to increase the number of black health professionals is performance in science courses at the college level. The current investigation used linear regression analysis to identify variables which predict grades in organic chemistry at Xavier University of Louisiana, a historically black institution. When only measures available on admission to college were used, high school grade point average was the best predictor for both semesters of organic chemistry (r=0.453 and 0.451). The accuracy of prediction was improved marginally by adding the ACT Composite score for the first semester only. When grades earned in previous chemistry courses were used, prediction improved markedly, as expected. The best

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predictor of grade for the first semester of organic chemistry was grade in the second semester of first-year chemistry (r=0.632), with grade in the first semester of first-year chemistry improving prediction somewhat. For the second semester of organic chemistry, grade in the first semester gave an r of 0.727, with grade in the second ~semester of first-year chemistry providing improved prediction. It is anticipated that this and similar studies will make it possible to improve advising of students, and provide direction in developing intervention strategies to help the underprepared.

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Black Americans are severely underrepresented in the natural and health sciences. Census studies show that black Americans constitute almost 12% of the nation's population (Census Bureau, 1983), but the National Science Foundation (1983) reports that less than 2% of the nation's scientists are black. In addition, as expected since health professionals usually major in science, the percentage of black health professionals in the United States is correspondingly low (Association of Minority Health Professions Schools, 1983).

Underrepresentation of black Americans (or any other minority group) in any profession is of concern, and it is of special importance in the natural and health sciences.

The lack of minorities in these fields is significant because it has led to reduced quality and availability of primary health care in minority communities. Davis and Davidson (1982) state:

> Generally, minority health providers, particularly physicians, are more likely to serve minority patients for a variety of reasons. Consequently the shortage of minority health practitioners has a direct negative effect on minority communities.

Also, the lack of minorities in the sciences lends credibility to fears that minorities will be excluded from key decision-making in our increasingly technological world. Finally, the low numbers of minorities in these areas denies society the untapped resources of minority groups. This weakens communities, the nation, and civilization as a whole. In view of these factors, continued efforts need to be made to increase the number of blacks and other minorities in the sciences.

If we are to make significant progress toward increasing the number of black Americans in science-related fields, both predominantly black and majority institutions must be involved in the effort. The importance of the predominantly black institutions is indicated by a report of the National Advisory Committee on Black Higher Education

and Black Colleges and Universities (1983). This report states that, while historically black colleges and universities enrolled only 17% of the black Americans in college in the late 1970's, they awarded 37% of the baccalaureate degrees received by blacks nationwide, and more than 50% of such degrees in states where the traditionally black colleges were located.

Studies of factors which impinge upon achievement by blacks in mathematics and science courses can be of considerable value in attempting to improve access of blacks to science-related careers. Organic chemistry is a subject of particular importance in this regard; it is a notorious stumbling block for pre-health professionals of all races. This paper describes a study of predictors for success of black Americans in organic chemistry at Xavier University of Louisiana, a small historically black institution in New Orleans. It is one of a number of studies designed to identify factors which lead to success in the sciences at this University.

Overview

Xavier University of Louisiana (XU) is a Catholic, liberal arts institution with a required core curriculum of forty-six semester hours outside mathematics and the sciences (and nine in those areas). Enrollment of full-time undergraduates has remained slightly more than 1,500 for a

number of years of which approximately 90% are black Americans. Although the overall enrollment at the University has remained relatively constant in recent years, the percentage of students in science-based programs has grown dramatically, and is now almost two-thirds of the total enrollment.

For several years XU has been #1 in the United States in placing black Americans into colleges of pharmacy, one of the top five schools in the nation in placing blacks into medical school, and a significant supplier of blacks for science graduate schools. The chemistry department has been a leader in this growth. In 1986-87, XU's Chemistry Department had 228 majors and produced 34 graduates, of whom 26 were accepted into graduate or professional school.

XU's two-semester organic chemistry sequence has several unusual features specifically designed to meet the needs of the underprepared students. Detailed descriptions of the sequence are available elsewhere (Sevenair 1979; Sevenair et. al. 1987). Under the general philosophy of focusing on exit rather than entrance criteria, the course is structured so as to combine high academic standards with academic support for all students.

The present investigation is one part of a comprehensive study of predictors of success for biology, chemistry, and pre-pharmacy majors at Xavier. These studies were initiated to improve advising, and to provide direction

when developing additional intervention strategies to help the underprepared. Students in these three majors can be grouped together because they take roughly the same sequence of mathematics and science courses during the crucial first two years, when most attrition occurs.

There have been very few previous attempts to identify accurate predictors of grades in organic chemistry. Pickering (1985) found high correlation coefficients (greater than 0.6) between general chemistry and organic chemistry grades. Using somewhat different methods, Steiner and Sullivan (1984) found a surprising negative correlation between experience in mathematics and score on the mathematics section of the ACT test, on the one hand, and success in organic chemistry on the other. Also of potential interest, and more frequently studied, are predictors of success in first-year chemistry. Such studies have examined traditional criteria such as high school grade point average, high school chemistry grade, and mathematics SAT score (Oszogomonyan and Loftus 1979, Andrews and Andrews 1979, Pickering 1975), and less traditional predictors such as Piagetian developmental level (Wiseman 1981, Herron 1975). A previous study at Xavier (Carmichael et. al. 1986), which considered the same group of students used in the present study, showed that traditional variables were successful in predicting grades for black college students in XU's general chemistry sequence. Other Xavier studies

have shown similar success predicting grades in general biology (Hunter 1984), entry-level mathematics (Jones et. al. 1987) and general physics (Vincent et. al. 1987).

This trend of successful prediction of science grades from traditional criteria has limits however. All of the above studies were at majority institutions where most students under study were non-minority students (presumably) or at Xavier where most were black. Therefore, they do not address the issue of whether or not traditional criteria predict for blacks at a predominantly-white institutions. Further, it is unlikely that they do since some studies (Borgen 1972, Temp 1971, and Scott and Shaw 1985) indicate that they do NOT do so for more general success in college.

These above suggest a number of questions to consider in the present investigation.

(1) Can traditional variables predict performance of black Americans in organic chemistry at a traditionally black institution? If so, what is the predictive procedure?

(2) Specifically, does performance on the math ACT correlate negatively with performance in organic chemistry?

(3) What implications can be drawn from comparison of this study with past investigations?

Procedure

Organic chemistry at XU is a two-semester sequence; the course numbers are Chemistry 2210 and Chemistry 2220.

Readily available variables found to have predictive power in similar studies were chosen for study as potential predictors of grade in Chemistry 2210 and 2220. They were:

...High school grade point average (GPA) on a 4.0 scale,

...Composite score on the American College Testing Program (ACT) test, and scores on the four subsections (mathematics, English, natural science, and social science) on the established 1 to 36 scale,

...Scores on the three portions of the Nelson-Denny Reading Test (vocabulary, comprehension, and total) in terms of grade level equivalents,

...Sex of student, and

...Grades in first-year chemistry (Chemistry 1010 and 1020).

The population under study consisted of 141 students who entered Xavier as freshmen, were majoring in one of the three fields under study (biology, chemistry, or pre-pharmacy), and subsequently enrolled in Chemistry 2210 in 1982-83 or 1983-84. This was approximately one half of the total enrollment in organic chemistry for those two years. The remaining students in the course either did not have ACT scores on file, did not enter Xavier as freshmen, or were majoring in other fields. Of the 141 who took Chemistry 2210, 112 subsequently enrolled in Chemistry 2220 and were used in the analysis of that course.

Predictors of Grades in Chemistry 2210 and 2220

Analysis was performed using the Statistical Package for the Social Sciences (SPSS), Version 9. First, means and standard deviations were obtained for all variables associated with Chemistry 2210 and 2220. Numerical values were substituted for the alphabetical values of grades (A=4, B=3, C=2, D=1, and W or F=0), and a dummy variable was introduced for sex (Male=1 and Female=0). The grade in Chemistry 2210 was added to the list of Chemistry 2220 predictive variables. Means and standard deviations are given in Table 1.

Table 1. Means and Standard Deviations of Predictors for Students in Chemistry 2210 (N=141) and Chemistry 2220 (N=112)

	Chemistry 2210		Chemistry 2220	
Variable	Mean	Standard Deviation	Mean	Standard Deviation
Chemistry 2220 Grade	...	...	2.46	0.99
Chemistry 2210 Grade	2.46	1.07	2.76	0.86
Chemistry 1020 Grade	2.89	0.87	3.06	0.76
Chemistry 1010 Grade	3.03	0.85	3.17	0.78
High School GPA	3.10	0.59	3.16	0.59
ACT Composite	19.2	4.6	19.9	4.5
ACT English	18.8	5.8	19.3	5.8
ACT Mathematics	19.1	4.9	19.9	4.7
ACT Natural Science	17.2	5.4	17.9	5.3
ACT Social Science	20.9	6.5	21.6	6.5
Nelson-Denny Vocabulary	13.7	2.2	13.9	2.1
Nelson-Denny Comprehension	13.5	2.2	13.8	2.1
Nelson-Denny Total	13.7	2.1	13.8	2.0
Sex	0.37	0.49	0.34	0.48

While the numerical values are generally self-explanatory, some observations might be made. The means of all variables except sex increase in a regular way

from the first semester to the second semester of organic chemistry, a trend begun in first-year chemistry (Carmichael et. al. 1986). This result is expected, since students with lower scores suffer higher attrition. The value of the sex variable increased from 0.34 in the first semester of first-year chemistry to 0.40 in the second, and then decreased to almost exactly its original value in the second semester of organic chemistry. This indicates that the attrition rates of males and females are equal, but that females drop out more rapidly at the beginning of the two-year period, while attrition of males is slower.

Next, Pearson correlation coefficients between Chemistry 2210 and 2220 grades and each of the potential predictor variables were calculated. These correlations are presented in Table 2. All were significant at the .001 level.

Table 2. Correlation Coefficients (r) Between Chem 2210 and Chem 2220 Grades and Each of the Independent Variables

Independent Variable	r with Chem 2210	r with Chem 2220
Chemistry 2210 Grade	...	.727
Chemistry 1020 Grade	.632	.585
Chemistry 1010 Grade	.611	.583
High School GPA	.453	.444
ACT Composite	.445	.334
ACT English	.290	.276
ACT Mathematics	.396	.201
ACT Natural Science	.349	.320
ACT Social Science	.409	.288
Nelson-Denny Vocabulary	.350	.217
Nelson-Denny Comprehension	.277	.242
Nelson-Denny Total	.331	.252
Sex	-.143	-.185

Many of the correlation coefficients are sufficiently large to have use in predicting grades in organic chemistry. Grade in the two semesters of first-year chemistry gave the highest correlation coefficients, while high school GPA and ACT composite gave the best prediction of the factors available on admission. The very high value for the correlation coefficient between the grades for the two semesters of the organic course is not surprising, since success in the second semester of the course is heavily dependent on knowledge and understanding from the first semester. Correlation coefficients for all of the variables with course grades decline from the first semester to the second; since the knowledge, lives, and abilities of students change over time, this is perhaps not surprising. This pattern of decreasing correlation does not hold for most of the predictors if the first-year chemistry

correlations are included (see Carmichael et. al. 1986 for coefficients for first-year chemistry). For the ACT test and all subtests, correlation coefficients with grade ~decrease from the first semester to the second, increase again to the third (first semester of organic), and decrease again to the fourth semester.

Multiple linear regressions (best least squares fit of a straight line in multi-dimensional space) were completed for both Chemistry 2210 and 2220. Variables are added one at a time so as to obtain the maximum increase in the multiple correlation coefficient R at each step, until adding more terms failed to produce a statistically significant improvement at the 0.05 level. Before performing ~this analysis, the components of the ACT and of the Nelson-Denny Reading Test were dropped from consideration, because the high degree of correlation between the composites and their respective components indicated that composites and components were so interdependent that regression procedures might not be applicable. Subsequent multiple linear regression analyses using components rather than composites verified that use of components did not improve predictive power. The results of the linear regression with four predictive variables (high school grade point average, ACT Composite, Nelson-Denny Reading Total, and sex) are summarized in Table 3. All values were significant at the .001 level or beyond.

Table 3. Summary of the Stepwise Multivariate Linear Regression Analysis

Step	Variable Added	R	R^2 x 100	R^2 x 100
Chemistry 2210, course grades not used to predict				
1	High School GPA	.453	20.5%	...
2	ACT Composite	.534	28.6%	7.1%
Chemistry 2210, course grades included				
1	Chemistry 1020	.632	40.0%	...
2	Chemistry 1010	.680	46.3%	6.3%
Chemistry 2220, course grades not used to predict				
1	High School GPA	.451	20.3%	...
Chemistry 2220, course grades included				
1	Chemistry 2210	.727	52.8%	...
2	Chemistry 1020	.749	56.1%	3.3%

When grades from first-year chemistry were not used in predicting Chemistry 2210 grade, adding ACT composite to high school grade point average increases the variance of the grade explained by 7%, to 29% of the total. The remaining variables did not produce a statistically significant increase (at the 0.05 level) in predictive ability when added. The unstandardized predictive equation for Chemistry 2210 was found to be:

$$Y = .584(X_1) + 0.072(X_2) - 0.724$$

where

Y = Predicted Chemistry 2210 Grade with A=4, B=3, C=2, D=1, and W and F=0.

X_1 = High School Grade Point Average

X_2 = ACT Composite score

When grades in Chem 1010 and 1020 were used, adding the grade for first -semester chemistry increased the variance of the grade explained from 40% to 46%. The equation for Chemistry 2210 then became:

$$Y = 0.444(X_1) + 0.397(X_2) - 0.657$$

where

Y = Predicted Chemistry 2210 Grade, as above

X_1 = Chemistry 1020 Grade

X_2 = Chemistry 1010 Grade

When grades in previous courses were not used in the linear regression, no independent variable improved the prediction from high school GPA at the 0.05 level. The unstandardized predictive equation for Chemistry 2220 in this case was:

$$Y = 0.789(X_1) - 0.028$$

where

Y = Predicted Chemistry 2220 Grade

X_1 = High school GPA

Finally, when grades in previous courses were used in the equation, addition of the grade in Chemistry 1020 improved prediction from 53% to 56%. The unstandardized predictive equation was:

$$Y = 0.681(X_1) + 0.289(X_2) - 0.301$$

where

Y = Predicted Chemistry 2220 grade

X_1 = Chemistry 2210 Grade

X_2 = Chemistry 1020 Grade

Discussion

(1) Can traditional variables predict performance of black Americans in organic chemistry at a traditionally black institution? If so, what is the predictive procedure?

Table 2 indicates that almost all of the traditional predictive variables under consideration have reasonable predictive power for Chemistry 2210, and some of them retain this power for Chemistry 2220. The best predictors for both the first and second semesters of organic chemistry were the grades in previous chemistry courses. If these grades were omitted from the procedure, high school GPA was best, with ACT Composite giving almost equal correlation for the first semester. Of the six correlation coefficients below 0.3, five are related to verbal abilities; one is with the ACT English test, and four with Nelson-Denny components and composite.

(2) Specifically, does performance on the math ACT correlate negatively with performance in organic chemistry?

Although the negative correlation found by Steiner and Sullivan (1980) was not reproduced for this group of students, the correlation coefficients of Table 2 between math ACT and the second semester organic chemistry grade (r=0.201) was the lowest found in this study. Steiner and Sullivan suggested that "Students come into the organic sequence believing that the old methods will continue to work, and fail to make the cognitive adjustments necessary

[to deal with organic chemistry, which has different cognitive requirements]." It may be that the very unusual nature of Xavier's general chemistry sequence (see Carmichael et. al. 1985, Carmichael et. al. 1987), which has a number of features specifically designed to improve cognitive skills, overcomes some of the problems noted by Steiner and Sullivan.

The weak correlation of performance in organic chemistry with measures of both verbal and quantitative ability indicates that organic chemistry is an unusual discipline, since it does not seem to be related to either of the major cognitive skills we associate with success in college.

(3) What implications can be drawn from comparison of this study with past investigations?

The results of a large number of studies show that procedures like those used in this study are successful in predicting the academic performance of majority students at majority institutions, both in chemistry and outside it. The study reported here shows that the same is true for minority students in organic chemistry at a minority institution, and the other studies at Xavier (Hunter 1984, Jones et. al. 1987, Vincent et. al. 1987) have shown that successful predictions can be made for such students in other content areas. The question of why these measures fail for minority students at majority institutions, and

occasionally at other times, is of some importance, both to those interested in the interpretation of studies of this type, and to those concerned with the specific academic difficulties experienced by minorities.

The authors propose, given the results of numerous studies of this type cited above, that high values of R (.45 to .65) are to be expected when predicting grade with traditional indicators. Predictor studies may then serve as a warning system. Low R values (less than 0.4) could indicate that a noncognitive factor, possibly a cultural one, is interfering with the academic process. If so, predictor studies could provide direction as individual schools seek to improve minority performance in their science programs. If predictor studies yield high R values, it is likely that emphasizing academic skills will yield the greatest improvement. If, on the other hand, R values are low, perhaps equal emphasis should be placed on developing support systems which attempt to deal with, and where possible overcome, the interfering non-cognitive factors. Research is needed to identify the specific non-cognitive factors which lead to the failure of traditional academic indicators on individual campuses, so that support strategies can be tailored to local conditions.

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